Energy Research & Social Science 78 (2021) 102127

Contents lists available at ScienceDirect

Energy Research & Social Science

journal homepage: www.elsevier.com/locate/erss

Innovative but unjust? Analysing the opportunities and justice issues within positive energy districts in Europe

Adam X. Hearn *, Annika Sohre, Paul Burger

Sustainability Research Group, University of Basel, Basel, Switzerland

ARTICLE INFO

Keywords:
Energy Justice
Capability Approach
Sustainability
Wellbeing
Energy transitions
Just transition
Positive Energy Districts (PEDs)

ABSTRACT

The current energy transition focuses on decarbonisation through the use of renewable energy sources, coupled with improvements in efficiency by means of technological innovations. However, there is also a clear call for realizing a just transition. The implementation of smart technology-led transitions and low-carbon energy system innovations is increasingly urged to become more people-centred by taking energy poverty and other justice related issues into account. Energy justice and energy poverty debates already transcend narrow foci on income and energy expenditure ratios and have moved towards multidimensional approaches (Bouzarovski and Petrova, 2015) [1]. In addition, the capability approach (CA) has been used to understand energy deprivation (Day et al., 2016) [2]. We further develop these approaches to better understand justice relevant issues within Positive Energy Districts, especially by looking at how opportunity spaces for realizing wellbeing are created. The primary goal is to establish a CA-informed framework for analysing justice-relevant issues within the development of Positive Energy Districts, based on a systematic literature search. Hereby we contribute to the discussion on usage of the CA within the field of energy and to the debate on how to frame technological innovations, such that they can contribute to a just transition.

1. Introduction

It is widely accepted that an energy transition is necessary [3–5], but timings, forms and potential pathways are manifold, and socio-technological innovations need to be critically examined in conjunction with energy justice [6]. Energy efficient or renewable energy technology is often costly to implement, leading to the potential creation of new energy systems that could exclude people who are not able to afford to adopt them [3,7]. In addition, the need to reduce overall energy use can be in conflict with the need to address issues of energy poverty [8]. Specifically, reducing consumer energy use through increasing costs is regressive and fails to protect the poorest in society. Basic energy services enable people to realize and maintain minimal wellbeing levels [9], but remunerating or subsidizing the energy vulnerable may lead to an increase in energy use and emissions [10]. Thus, it is not only about energy transitions, but specifically just transitions. Accordingly, in order to form part of a just transition, the implementation of technologically innovative living spaces, based primarily on renewable energy, needs to inherently take justice-related considerations into account.

Besides techno-economic approaches [11] and analyses of policy instruments fostering implementation [12], recent research has contributed towards a better understanding of some of the social dimensions of the energy transition [6,13,14] and has taken up concerns regarding energy poverty/vulnerability [8,15,16]. In addition, wellbeing issues related to energy have been examined [17,18] and there have been attempts towards broader multidimensional approaches to energy justice [1]. However, how Positive Energy Districts (PEDs) [19–22] can contribute to a just transition is unclear. Whilst there has been research on the low carbon energy transition [23], studies on the link between technologically innovative living spaces which incorporate multiple low carbon innovations and justice are underrepresented in the literature [24], and a systematic framework or approach, which especially allows ex ante study of justice and wellbeing issues related to PEDs, is missing.

PED-like areas are new and highly interesting study objects within the realm of the energy transition. The EU launched a programme to support the planning, deployment, and replication of one hundred PEDs by the year 2025 [19,22], aimed at speeding up decarbonization [20]. These could be considered to be holistic smart energy systems, as they

* Corresponding author.
E-mail address: Adam.hearn@unibas.ch (A.X. Hearn).

https://doi.org/10.1016/j.erss.2021.102127
Received 19 November 2020; Received in revised form 14 May 2021; Accepted 19 May 2021
Available online 27 May 2021

are broader urban living- areas characterized by

1: Net-positive renewable energy production on a yearly basis (the "positive" part of PEDs); highly energy efficient buildings (enabling the district to rely purely on renewable energy may require significant reductions in energy consumption); and a degree of energy flexibility.

2: Inclusivity, affordability, sustainability and allowing for a high quality of life

3: A governance framework that actively encourages citizen participation [22].

Bringing together a variety of smart energy system innovations, such as smart meters, electric vehicles and renewable energy [25], energy flexibility [26,27], coupled with elements of social change and changes in energy ownership, makes PEDs captivating areas to study. Specifically, basing PED creation on principles of inclusivity and affordability encourage a focus on justice issues which may not be as prominent in other smart energy systems. PEDs are however still in their infancy, and currently more of an aim than a reality [21], because of the difficulty in achieving an annual surplus in renewably produced energy, and most districts aiming to become PEDs could be referred to as *PED-like* areas. Nevertheless, the initial 100 PEDs are likely to be followed with significant replication and these districts may become a new standard within a decarbonised Europe, making energy justice issues all the more important if there is to be a just transition.

Whilst the energy justice potential of renewable energy has been examined [28], the novelty and innovation of these districts is that they represent not a single technology but require diverse (smart) technologies. Moreover, they are not only based on technological innovations but call for behavioural changes of the inhabitants. PED-like areas also go beyond the individual ownership-level of prosumers [29,30], extending to the scale of neighbourhoods or communities. As such, PED-like urban areas are enabled by a multiplicity of innovations and are thought to contribute to a just transition. However, in what respect they do so is an open question.

Our goal is to pave the way for a framework that allows ex ante study of justice and wellbeing issues in PED-like areas. To this aim, we employ the Capability Approach (CA) to inform the public discourse on energy justice because it provides a multidimensional normative approach suitable for linking justice and wellbeing [31,32]. Specifically, we fill the gap highlighted by Hillerbrand et al. [32], who identify the need for further research on whether and how energy capabilities need to be adapted for large-scale smart technology districts such as PEDs, and more directly to understand energy justice issues in these settings. Embedding PED-like areas with justice and wellbeing issues (rather than energy supply and consumption only) could contribute substantially to a just energy transition. Accordingly, our research strives to answer the following research question: What are the main energy justice and wellbeing related elements that need to be accounted for to ensure PED-like areas are part of a just transition?

To answer our research question, we first detail our methodology in section II. In section III, we distil major energy justice categories characterising "just" from the literature and rely on the CA. Against this backdrop, in section IV, we develop a framework directed to analysing PED-like areas building on the livelihood-based capabilities framework of Lienert and Burger [33]. This framework thus provides a general basis for ex ante assessments of energy justice considerations to inform designs and potential governance regulations of such areas. Our discussion in section V is based on an explorative study to demonstrate its usefulness, followed by a conclusion and outlook section (VI). This research adds to the literature by providing a robust theoretical basis for understanding justice issues in PED-like areas, as well as ex ante evaluation criteria to influence PED design.

2. Method

In this section we explain the three different methods applied in this paper to develop our framework, and provide some background information on the Swiss PED-like example. In order to develop justice and wellbeing related criteria for assessing the creation and development of PEDs, we perform a systematic literature search (Fig. 1), based on the terms "energy justice", "energy poverty" and "energy transition" so as to determine relevant generic criteria. We include energy poverty in our search as this is an important trait of the prevailing European energy system. We do not claim that our literature review covers all aspects of energy justice, as we focused on what was within the scope of our research interest. Additionally, we removed papers where the focus was on Global South. As we are going to rely on the CA for our framework (see below), we also conducted a google scholar search on the terms "energy justice" and "capability approach". In addition, we use a snowball search of articles.

Following a careful reading of the abstracts, we determined which papers were deemed to potentially contain insights relevant to building an energy justice framework. Out of that sample, we identify major energy justice-related categories to be included in the framework as well as those categories representing our theoretical commitment to the CA (section III). In order to develop a framework, we adjust a former livelihood-based capabilities framework (see below) to include the distilled energy justice categories. This results in an integrated framework with the goal of analysing PEDs in terms of their possible contribution to a fair transition (section IV). To demonstrate the applicability of our framework in the intended ex ante (and ex post) analysis of justice issues, we chose one PED-like example from Switzerland (cf. below). For this exploratory study we rely on the following data: written documents, one 2-day site visit and key informant interviews (section V).

The Hunziker Areal (HA) in Zurich is a PED-like district that will serve as an example for applying the framework in an exploratory manner and was established with energy justice issues in mind. HA is designed and managed by the housing cooperative Mehr als Wohnen (MaW) [34]. The site is 40.000 m^2 including 370 apartments, shops, restaurants, a guesthouse and 1300 + residents. The HA is part of the "2000 W Society" [35] which aims to reduce potential energy usage to the global average of 2000 Watts at any given time per person [36]. Reasons for the selection of the HA are that it is one of the more established PED-like sites (completed in 2015), with some literature already available, as well as populated enough to warrant study, whereas many of the other sites are currently still in development or smaller in size [21].

3. Major energy justice categories and the capability approach

In the following, we extract elements of the energy justice literature and the energy related CA-literature that allow us to consider generic criteria regarding what makes a transition a just transition.

Looking at said literature, the three-tenet approach to energy justice [24] has become quite dominant. It encompasses distributional, recognitional, and procedural dimensions [15,37–39]. Together with the additional dimensions of global and restorative justice (e.g. [40]), the three-tenets are thought to capture major types of inequalities [23].

The *distributional* part encompasses the distribution of material outcomes or public goods, as well as injustices suffered by ignored or misrepresented groups [24,41–43]. A just energy transition requires considerations to avoid negative impacts, including potentially novel negative justice impacts [44] and work to eradicate existing inequalities [45,46]. This is salient because the energy transition occurs in a sphere that is already regulated by a swathe of governance [39], with pre-existing distributional patterns for benefits and burdens. Recognizing pre-existing actors, processes and policies [47] as well as new variations which may arise throughout the transition allows us to identify potential distributional injustices. Distributional justice includes locational impacts arising from the production, transport and consumption of energy, such as the retraining of coal industry workers in Germany in the 1990s (some in renewable energy) to reduce social costs resulting from declines in coal output [48]. However, there is also growing evidence of

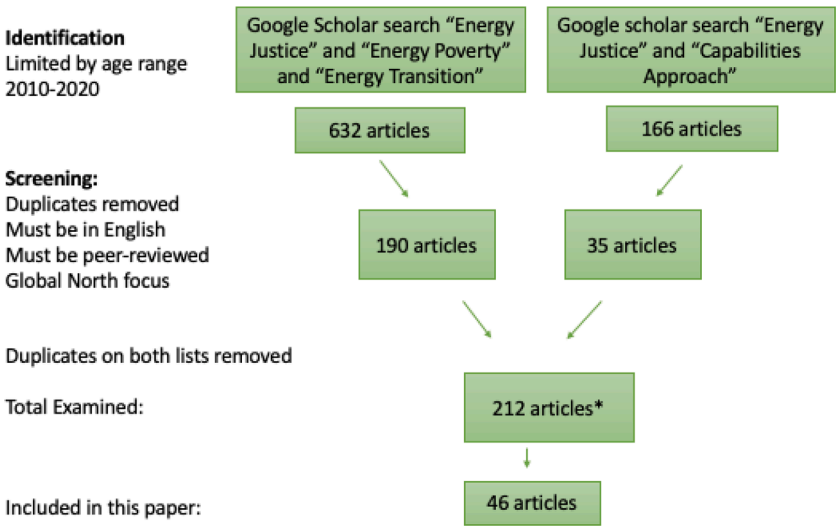

Fig. 1. Flow chart of the literature selection process.

job losses, greater public scepticism towards renewables and a slow-down in the sector's growth in Germany based on perceived unfair distributions of burdens and benefits [11] .

The focus on *recognitional* energy justice examines whether groups with differing energy needs (e.g. elderly or disabled people) are partially or completely overlooked, and how better to include these [16,37]. When it comes to just energy transitions, communities which are negatively affected by the distribution of burdens, such as those situated near large scale private wind parks [37,44,49], may see valid objections dismissed as illegitimate and NIMBYism.

Procedural aspects, related to decisions on the allocation of costs and burdens, are characterised by calls for greater inclusion in fair decision-making processes [16]. Procedural justice has become a more pressing topic because new types of actors, such as prosumers, challenge the longstanding dichotomy of consumer/producer [50]. For PED-like areas, this dichotomy is further challenged, with multiple new forms of energy production, ownership and management [51].

Global justice issues refer to the application of energy justice notions of distribution, recognition, and procedure, on a global scale, throughout the entire energy lifecycle [3] including aspects of resource extraction (e.g. Cadmium mining for photovoltaic panels production; [52]), production (e.g. nuclear energy production; [53]), distribution, and consumption of energy to ensure that it is just [23].

Restorative justice [40] focuses on mitigating energy injustices that have already occurred. Past injustices, unequal distribution of burdens, lack of recognition and procedural failures can be remediated through restorative justice [54].

An alternative approach [55] sees energy justice through the 10 principles of availability, affordability, due process, transparency, sustainability, intragenerational equity, intergenerational equity, responsibility, resistance and intersectionality. Without entering into a detailed discussion, we claim that most of them can also be seen as aspects of the previous five justice elements, with the exceptions of intra- and intergenerational equity. Both intra and intergenerational equity are elements which we believe should be included in an energy justice framework as they are fundamental justice dimensions within sustainability.

There are other approaches such as for example Bell et al. [56] that analyses energy systems through four intersecting dimensions, political, economic, socio-ecological and technological. This approach emphasises the injustices in the existing system and, accordingly that transitioning to renewable energy systems may require greater transparency and active intervention in order to truly support wellbeing. This once again highlights the need for frameworks that encourage examining justice issues within the context of fair energy transitions.

Although the referenced literature reveals manifold dimensions and approaches for analysing justice and wellbeing issues in an energy transition context, we take the five dimensions discussed above as a stable denominator guiding the discussion on just transitions, together with intragenerational equity (through the use of the CA) and intergenerational equity (through the use of a livelihood-based framework, cf. below). In addition, the sub-topic of energy poverty/vulnerability (energy deprivation in the home [1,8]) has also attracted scholarly attention and led to the development of multidimensional sets of criteria going well beyond income and share of spending for energy (e.g. [57]). This is an important line related to our topic because technological innovation is often only affordable to the wealthier. Furthermore, the development of PED-like areas will necessitate retrofitting programmes, revealing difficulties stemming from the complex interaction between relative poverty, technological measures, and how they are integrated into daily life [37,58]. However, energy poverty can be seen as encompassing and mirroring all the already discussed dimensions (distributive, procedural, recognitional, global, and restorative aspects). Furthermore, in terms of the CA, energy poverty is a form of capability deprivation [41,59]. It prevents individuals from having adequate energy services to the effect that they are deprived from opportunities necessary for living what they subjectively consider to be a full and valued life.

Whereas we can take the five dimensions of justice as sketched above as a basis for analysing justice related issues within the energy transition, the literature discussed is often lacking (a) a sound normative justice approach and (b) a qualitative understanding of human well-being. Both lead us to the normative dimension of what ought to be the case. Ex ante assessments of technologically innovative settings like PEDs become possible only by adding an approach highlighting desirable energy future. For this normative dimension we adopt the CA (We debate its merits extensively in further publications, e. g. [92]).

As mentioned earlier, the CA has been applied to energy poverty providing a normative foundation [2], which we build on to synthesize the CA with energy justice. The CA has been used as a metric of well-being and justice, and takes opportunity spaces [31], freedoms to choose what one has reason to value, as normative currency (metric of justice). The underlying normative criterion for wellbeing is to be able to live the life that people have reasons to value. Moreover, the CA follows a multi-dimensional understanding of wellbeing, not taking an aggregated criterion like life-satisfaction. Capabilities are formed through societal and natural conditions and unjust states of affairs come about through the missing of central capabilities, normally labelled as capabilities

deprivation [2,41]. The justice criterion is that the normative metric holds for all (currently living and in future living) individuals. In our field of interest, energy injustices (e.g., lack of access to clean energy) display capabilities deprivation. Moreover, the underlying multidimensional understanding of wellbeing goes well together with multidimensional understandings of energy poverty or vulnerability. In addition, energy consumption or overconsumption could also adversely affect the opportunities of other people (whether in the present or the future) to live a life they value [60].

Relying on the CA, a just transition is then one in which manifold capabilities are available for all, intra- and intergenerationally, and not impinging on the capabilities available for others elsewhere. Lists of core capabilities such as those given by Nussbaum [41] have also been used to examine energy justice [32,61] with a focus on distributional justice. A significant difference in our approach is that like Sen [62], we leave capabilities undefined, accepting that different people and societies may value capabilities in divergent ways [42]. There is also an ongoing debate within the CA on whether to empirically examine achieved functionings, what people actually do or have based on their available options, or input factors, that create the opportunity spaces. However, achieved functionings are beyond the scope of this paper, and primarily relevant when assessing realized impacts coming out of interventions/policies, whereas we are mainly interested in ex ante criteria for designing PED-like areas. In addition, and methodologically speaking, realized functionings need to be identified by asking the affected individual. In parallel to what is being done by the HDI (Human Development Index) [63], we look at inputs (in our terminology, *capitals*), that create opportunity spaces through the design of PEDs and related policies. This is also similar to Belda-Miquel et al. [64] who incorporate the CA into an energy justice framework in terms of people's ability to achieve a life they value, by looking at the need to include the structures that enable human flourishing, for grassroots energy innovations. We go beyond this by focusing on PEDs which are a form of top-down governance energy innovation.

Hence, we take out of the existing literature that our approach should (a) display the five dimensions of recognitional, distributional, procedural, global and restorative justice discussed in the energy justice literature and (b) be informed by a normative sound justice approach based on a multidimensional understanding of wellbeing, for which we have chosen the CA.

4. Integrated framework of energy justice and wellbeing in energy transitions

Whereas section III focused on generic criteria for what could make up a just transition, this section is directed to the specific topic of technologically innovative living spaces. In line with section III our framework builds on the following considerations:

(a) As far as justice related issues are involved, distributional, procedural, recognitional, global and restorative justice, as well as intergenerational and intragenerational justice need to be included.
(b) PED-like areas are interesting because they create living spaces, hence they influence people's wellbeing. They are thought to contribute to a just transition and are meant to be human-centred. Hence, wellbeing considerations take centre stage.
(c) As (a) and (b) are different, albeit strongly interlinked, we have chosen a theoretical approach that offers an established approach to both, the CA.
(d) However, as the CA provides a normative framework but not necessarily a framework for empirically examining the relation between innovation and how people will embed it into their daily life (behaviour) to realize wellbeing, we need to consider additional frameworks for analysing such topics.
(e) Among the two possible options here, analysing input factors (opportunity spaces) or realized individual wellbeing, we opted for the first. A full framework would also include the individual wellbeing or output. Research highlights that although wellbeing cannot be reduced to happiness or emotionally feeling well, the latter is a significant component [65,66]. Including realized individual wellbeing would not only ask for further theoretical resources that go beyond the scope of this paper, but is hardly feasible given that most PED-like areas are in a very early stage of being realized.
(f) Accordingly, we adapted the livelihood-based capabilities framework ([33], Fig. 2 below) developed in a different context as this provides an approach to analyse input factors for realizing wellbeing. This framework merges a sustainable livelihoods approach with the CA, recognizing that access to different types of resources (capitals) is a prerequisite for wellbeing [67].

Originally, the framework has been used for assessing impacts on human wellbeing stemming from the valuation of biological resources in rural parts of Nepal. One of the benefits of this framework is that it includes the element of intergenerational justice which may be somewhat neglected with the use of the CA alone. However, the focus of this framework was also on input-factors rather than the perception of wellbeing. Moreover, looking at these five types of capitals or input resources is a standard in the livelihood literature. The framework invites us to examine opportunity spaces, the basic building blocks which are necessary for building assorted capabilities. From these capabilities, individual choice and livelihood strategies are developed, resulting in valued functionings. In what follows, we adjust the original framework to serve for our analytic endeavour (Fig. 3).

A first specific element to look at are energy services provided by PEDs. This is also in line with Day, Walker and Simcock [2] who consider access to energy services a crucial input factor for capability spaces. Moreover, and also in line with recent research in the social sciences energy services are key to understanding energy demand. People do not consume energy for the sake of energy, but *use* energy services [68]. As such, energy consumption as well as the related CO_2-emissions are a side-product of mostly routinized behaviour [7,69]. Energy services also establish a direct link to smart technology innovations, because innovative energy services are almost always smart technology-based. Moreover, energy services also outline the purpose for which they are used. However, when looking at PED-like areas, there are broader sets of input factors to look at than just technology. The five capital dimensions captures the following:

Physical capital deals with infrastructure and technology, heating and electricity system and provides and restricts effective opportunities by inducing trade-offs if the quality of the physical capital is not optimal [67]. Energy justice issues such as those concerning flexibility products in smart energy systems would be situated under physical capital [26].

Natural capital is concerned with the environment; land availability, geographic setting, water and natural resources, including sunlight hours, vital for electricity generation through PV panels, as well as wind (for wind turbines) and proximity to bodies of water (hydropower). Natural capital is spatial [70], and also deals with the ecology of a district and how this is affected by energy justice choices. We include the environmental frame conditions from the original framework within Natural capital. *Financial capital* refers to income generating activities, available property, affordability, financial resilience and good governance. Access and availability are crucial in the context of implementing technological smart energy innovations, and in addition transport poverty and mobility issues (e.g. fuel prices and vulnerability, [71]) could be included under this heading. *Human capital* refers to the education and knowledge base, a person or group of people have access to. For people to reduce their energy consumption it is, for example, imperative that they understand what they consume and when to adopt new energy saving behaviours. Human capital includes examining

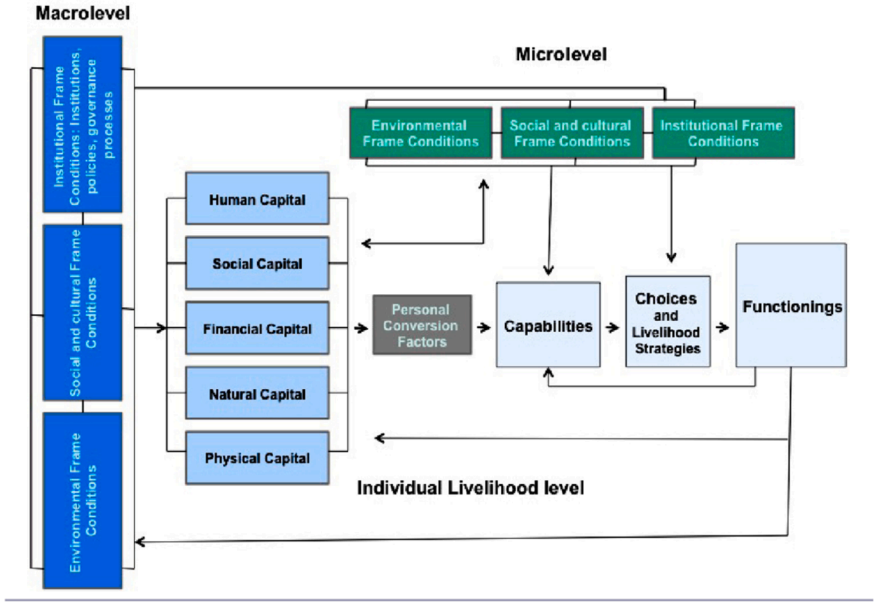

Fig. 2. Lienert-Burger 2015 livelihood-based capabilities framework from a sustainability perspective.

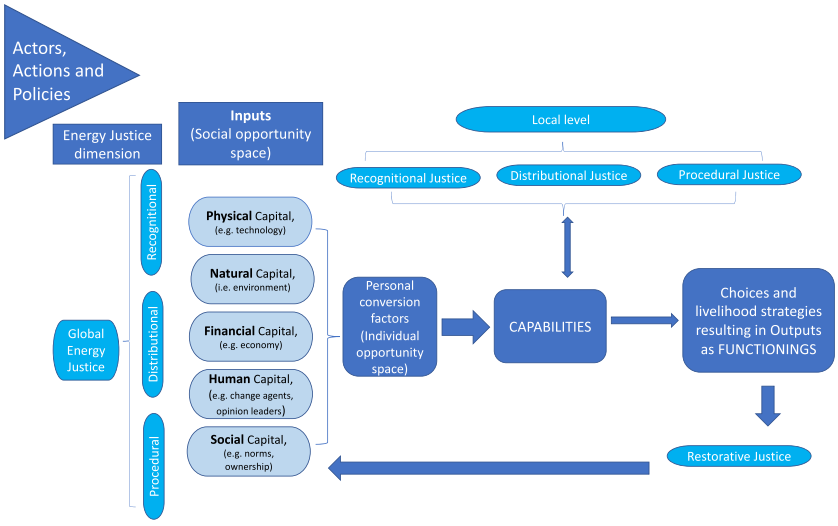

Fig. 3. The five capitals Burger Lienert model adapted to provide an energy justice framework.

change agents, as in the case of small business owners in Germany following the Chernobyl disaster [70], or energy cooperatives in Spain [50]. This relates to *Social capital*, which includes all kind of social relations like membership of groups, participatory processes health and medicine, and a social circle that enables or supports a person in her agency. Social capital also includes race and gender issues [56,72], and we include the social and cultural frame conditions from the original Burger-Lienert framework within social capital.

The five capitals set the scene for the opportunities available to residents, who are then able to choose those that they as individuals prefer. However, the capitals are embedded in a broader setting and can also be influenced by political actors, structures and actions [47]. In order to adapt the framework to smart technology innovation settings, we replaced the environmental, social and cultural, and institutional frame conditions with distributional, procedural and recognitional justice dimensions as well as situating these under global justice, and adding restorative justice. The original frame conditions would be unproblematic if we were solely examining wellbeing and sustainability (as intergenerational justice) but we believe it important to highlight other significant energy justice dimensions. Examining these elements and their effect on the physical, natural, financial, human and social capitals allows us to see the capabilities which are available to residents after also taking into account personal conversion factors. By framing energy justice in this way and enriching the livelihood-framework with conceptualizations of the energy justice discourse, we can see that it is not solely about what people have reason to value and the individual capability set they may choose, but also about providing the opportunity spaces for all, including future generations. We place the framework under a triangular flag of "Actors, actions and policies", indicating that these play a significant role in determining the capitals available to a district.

To summarize, the following four points are essential if PED-like areas are to be considered from an energy justice perspective, informed by the CA approach, with a focus on wellbeing and

opportunity spaces. First, the framework distinguishes generally between the individual and aggregated levels for energy justice and energy poverty, by looking at individual wellbeing as well as structural enabling conditions. Second and regarding PEDs, it examines justice considerations *within* PED-like areas along the dimensions of distributional, recognitional, procedural, global and restorative justice and puts opportunity spaces and how these enable wellbeing through the capitals (Fig. 3) centre stage. Simultaneously, the incorporation of global justice serves as a reminder that the impact of decisions taken related to the capitals may be international. This is mainly an ex-ante assessment, however it can also be used to examine PED-like areas ex post. Third, it opens the door for looking at governance implications. Although it can also be used for ex post analysis (looking at realized wellbeing for example), it can be used for ex ante assessments regarding requirements for *creating (designing)* energy just PED-like areas.

Fourth, this capitals informed capabilities framework could, for example, be linked to change of behaviour-related frameworks as outlined in Burger et al. [47]. Bringing such a behavioural framework into the picture draws the analytic attention beyond the enabling conditions to include how people adapt technology innovations to their daily life. This not only concurs with recent research on reducing energy consumption pointing to both structural and individual aspects [73,74], but mirrors again that the framework displays individual and aggregated structural levels. However, we did not carry out that last step due to the existing space limitations.

5. An application to the Hunziker Areal, Discussion.

In this section, we seek to demonstrate the usefulness of our framework with an application to the Hunziker Areal (HA). We look at the five types of capitals to see in what respect ex ante decisions in the creation of the HA provided opportunity spaces by taking justice dimensions into account. The following tables chart some of the energy justice issues related to each of the capitals in the example of the HA, which we will also discuss in relation to other PED-like areas. Moreover, we discuss the benefits of our framework and point to limitations.

The HA was purpose-built, and the extensive planning phase incorporated the voices of multiple experienced collectives (see social capital below). It is likely that this will not be the case for all PEDs, impacting physical capital and natural capital as the spatial distribution is less flexible and existing infrastructure is likely to be used as the basis for improvement. This may lead to very different debates, as retrofitting existing multi-occupancy buildings and those in co-ownership may have complex legal and governance issues when it comes to energy saving and generating installations [75]. The retrofitting of older housing stock [37,58] could be viewed through the lens of restorative justice, perhaps giving further impetus to the creation of PED-like areas in deprived areas.

All 2000-W society districts in Switzerland have common energy reduction aims [76] and are purpose-built with long term tenants in mind (cf. [77]; 65% of housing stock in Switzerland is tenanted, [78]). The 2000-W society is part of the national energy policy and is promoted by the Swiss Federal Office of Energy (SFOE). Having a supportive policy context is a significant benefit when it comes to creating PED-like areas, and drawing policy makers attention to the five capitals could potentially lead to more energy-just districts.

In the area of technology and infrastructure, i.e. *physical capital* (Table 1), there has been research on the need for public acceptance, as well as the need to guard against unintended social consequences; areas of procedural and recognitional justice [11,14]. Decisions made regarding physical capital at the HA were reached through a variety of activities such as an ideas competition, ideas market, working committees, events and themed workshops, between 2010 and 2015. Cooperative members, the wider public and the project developer exchanged ideas on sustainability, building services technology and new apartment typologies [79]. The way these decisions were made has repercussions for procedural and recognitional justice, going beyond using participation as a means of gaining public acceptance. The shape and direction of the district was determined through participatory processes which attempted to gather together the best choices and preferences for a new district from an actively engaged public. Indeed physical capital is not normally part of the decision-making remit for tenants, and PED-like areas such as Carquefou (Nantes, France, [21]) offer apartments for sale, excluding some of those who are unable to afford to purchase them (although some 20% social housing is planned [21]). On the other hand, decisions regarding energy consumption and heating in the HA may result in global justice issues, specifically with regards to the choices of building materials used, source of energy and heating mix and its impact on GHG emissions. This is also the case in connection with social capital in solar communities in Portugal [6] which were hesitant to invest in new technologies due to global justice issues, such as the working conditions and source of raw materials for PV panel production. The choice building material for the HA is cement which in turn means the buildings have high embodied carbon emissions [80] and although these are more sustainable to live in, they are not necessarily sustainably built.

In terms of *natural capital* (Table 2), living in an area with no other residential buildings around it may have initially resulted in a reduction of the opportunities associated with city living, whilst the surrounding

Table 1
Physical Capital and justice issues in the Hunziker Areal.

PHYSICAL CAPITAL	Hunziker Areal MaW 2000-W	Energy Justice Dimension
Electricity	60% of energy imported from national grid, around 40% from PV panels	*Distributional:* costs and benefits of production, storage, transmission; location of PV panels *Procedural:* how decisions regarding energy supplier are reached *Global:* choice of energy mix, where PV panels are produced
Heating	Waste heat harnessed for district heating	*Distributional:* not all districts can harness this, future residential areas may not be able to benefit from this. *Global:* no incentive to reduce waste heat if this is to be harnessed, could lead to increased emissions. Potential rebound effect *Intergenerational:* long term reduced costs and wellbeing standard
Infrastructure	Purpose-built to Swiss Minergie standards	*Global/Intergenerational:* Minergie buildings are not necessarily sustainable to build with lots of concrete and high embodied carbon emissions. *Distributional:* benefits and burdens of Minergie, such as not opening the windows for lengthy periods, but also high energy efficiency.

Table 2
Natural Capital and justice issues in the Hunziker Areal.

NATURAL CAPITAL	Hunziker Areal MaW 2000-W	Energy Justice Dimension
Spatial within city	No other residential buildings (surrounded by light industry). Outside city centre, accessible via bike trail, footpath, train or bus	*Distributional:* not in a standard urban area *Recognitional:* easily established boundaries of those affected by decisions made in the district, and easier to identify vulnerable residents
Distribution within district	Smaller private spaces, larger shared spaces (shared guest rooms for visitors, party rooms, freezer room, parks etc)	*Distributional:* particularly during the COVID-19 pandemic where shared spaces may be perceived as riskier

industrial area would have also meant none of the expected benefits associated with living in less populated areas with green spaces materialised (Distributional injustices). Private spaces are small, with an emphasis on shared spaces (both indoors and outdoors) and shared living, which could be taken as meaning that there is greater spatial equity within the district. This spatial distribution [70] makes for more efficient energy use but also raises wellbeing issues. Although there are alternate ways of enhancing capabilities provided, this form of semi-communal living may not be easy to adjust to for those that are used to larger private spaces. The need to quarantine and social distance during the COVID19 pandemic also brings the benefits of this type of spatial distribution into question.

In terms of *financial capital* (Table 3), we identify affordability, income generating activities and mobility as key areas. A significant deposit is required from residents (10.000–28.000 CHF depending on property size), representing around eight months' worth of rent. Rents are estimated to be 20% lower than in similar sized properties elsewhere in Zurich and it is claimed that owing to this, banks may be amenable to loaning a deposit making the funds potentially easier to secure. Additionally, 10% of the housing available is given to social institutions and provided to people who cannot pay the deposit, thus enabling some energy vulnerable people to benefit, with rent varying from case to case depending on need. Energy prices within the HA are set by the collective to deliberately be among the highest in Zurich, in order to encourage energy-saving behaviour. This is counter-balanced by the highly energy-efficient infrastructure, and may indeed be considered to have an effect on global justice as the implication is that emissions from the district will be mitigated. On the other hand, the extra cost of this may be perceived as an energy injustice for the 10% living in social housing.

There is a risk that PED-like areas will result not just in the exclusion of energy vulnerable people, but also in the exacerbation of energy poverty [58] and the potential ghettoization of the energy poor. PED-like areas such as La Pinada (Valencia Spain, [21]) already face some public objections along the lines of exclusion, as future residents are encouraged to sign up and co-design the neighbourhood, but for a price of €600 [81] which is likely to be beyond the reach of the energy vulnerable.

Table 3
Financial Capital and justice issues in the Hunziker areal.

FINANCIAL CAPITAL	Hunziker Areal MaW 2000-W	Energy Justice Dimension
Affordability	Rents 20% lower than average for Zurich, energy deliberately priced as highest in Zurich, Large deposit required.	*Global:* high energy prices may help reduce demand and associated emissions *Distributional:* greater negative effect on those in social housing *Procedural:* who gets to live in the district and how are they selected?
Mobility	All residents (bar disabled and shift workers) sign a car waiver Ecar sharing scheme Ebike/cargobike/bike rental	*Intergenerational:* more sustainable mobility options promoted *Intragenerational:* potential negative effect on elderly and families with small children *Recognitional:* some people with different needs are treated differently
Income-generating activities, available commercial property, financial resilience	Ground floors kept for businesses Approx. 150 people employed in or by the HA	*Distributional:* who benefits from working in the area? How do salaries compare? *Procedural:* how are decisions reached on which businesses should operate within the district?

Furthermore, in terms of mobility, which we include under financial capital, there are significant justice issues within the HA. Effectively trade-offs have to be made in deciding whether sustainability is more important, with a focus on global and intergenerational energy justice, or whether some elements of subjective wellbeing such as the convenience of owning a vehicle/being able to park in the district etc. may need to be curtailed. Ultimately, the decision to provide an electric car-share scheme in the district may mitigate this, but the embodied emissions in these vehicles and the global energy injustices associated with them make this potentially a "less-unjust" option rather than a truly just option. Ensuring that the district is walkable and cyclable and that residents are able to meet their needs without venturing further on a regular basis has perhaps a great impact on mobility energy justice.

For the development of PED-like areas, it is worth noting the potential energy injustices connected to *where* finance comes from and for what purpose. This is particularly important because JPI Urban Europe estimates that the €0.74 billion public investment will be met with minimum of €100 billion from private investment and cities [82]. If these districts are to be run for profit (such as the case of La Pinada, Valencia [81]), reiterating the need for a just transition becomes all the more important to avoid them becoming exclusively the domain of the wealthy. Whilst potential impacts of energy finance on justice issues have been previously examined [83], putting this in the greater context of the 5 capitals allows a wider picture of energy injustices to be revealed.

There has been significant focus on *human capital* (Table 4) from a gender perspective [56,72,84], however within the example of HA gender remains to be examined, and this would indeed be grounds for future research. Having an experienced knowledge base formed from multiple other cooperatives may have led the HA to make the decision that the district should mirror demography in the greater Zurich area in terms of inhabitants age, gender, income-bracket and nationality.

As apartments become available, these are not rented on a first-come first served basis, but interested parties are invited to apply, and a committee has the final say on who gets to rent the place (note: there is a shortage of apartments in the Zurich area and it is common for landlords to select tenants based on their own sets of criteria [78]). This suggests that the assessment is not needs-based which could further add to injustice.

The demography of HA was meant to mirror the wider community but salaries are slightly lower than average, and there is significantly greater representation of international residents (in terms of recognitional justice, this may cause some difficulties in communication) as well as those with special needs. For those with special needs, car ownership is permitted (intersecting with financial capital, Table 3), and this may help mitigate some potential recognitional justice issues.

In terms of *social capital* (Table 5), it is possible to join the cooperative, without being a resident. This brings in a number of potential justice issues in that members of MaW do not have to live in the district

Table 4
Human Capital and Justice issues in the Hunziker Areal.

HUMAN CAPITAL	Hunziker Areal MaW 2000-W	Energy Justice Dimension
Knowledge base available Opinion leaders/change agents	Created by members of 30 different cooperatives. Participation actively encouraged with 300 + members of WhatsApp and Telegram groups for residents	*Procedural:* significant knowledge base *Recognitional:* newcomers may face established and entrenched roles. Some people may be excluded from forms of digital communication
Demographics	Greater representation of residents with special needs, immigrants and refugees (over 60 nationalities represented)	*Recognitional:* greater recognition of these groups, but potential language barriers

Table 5
Social Capital and Justice issues in the Hunziker Areal.

SOCIAL CAPITAL	Hunziker Areal MaW 2000-W	Energy Justice Dimension
Social groups	40 + social clubs (e.g., beekeeping, sauna users, carpentry) open to general public, minimal membership fees	*Procedural:* processes clearly set out, affordable and accessible *Recognitional:* require only 5 people to form a new club
Ownership	Cooperative, all residential units tenanted, no individual home owners	*Recognitional:* it is possible to be a member of the cooperative but not a resident. This would entail having a say in what is done but not necessarily being equally affected

to have a say in what occurs in the district. Decisions are made democratically, and the voice of the minority members that do not live in the HA may be instrumental when it comes to voting on issues upon which residents are relatively evenly divided. In addition, social clubs in the HA are open to the wider community outside of the HA, and membership is fee-based. However, clubs are also supported through the solidarity fund which receives income-dependent contributions from residents, meaning that most of the infrastructure is provided at a low cost or is free. This may mean that HA clubs are likely to be more affordable than those in other areas, but also raises questions on fairness and whether non-residents are contributing fairly. It also increases the social opportunity space for those who attend whilst attempting to encourage positive attitudes towards the HA from both residents and non-residents. There are, accordingly, numerous opportunity spaces created for social interaction, whereas it remains up to the individuals to participate.

Taken together, our justice framework expands the focus away from environmental (which we include as natural capital), technological and economic justice dimensions to include other dimensions which may otherwise be understudied. When applied to other PED-like areas, our framework may reveal that human and social capital will likely be crucial in ensuring energy injustices are minimized. A study on communal bioenergy projects in Germany [85] indicated the importance of human capital in the form of initiators. It is possible that PED-like areas will also better develop in areas where local participation is stimulated by change agents. Ownership and co-ownership issues in PED-like areas may arise where there is a need to motivate residents in order to increase demand side flexibility, improve energy efficiency and attempt to deal with energy poverty [86] bringing in multiple justice dimensions. Energy justice approaches to renewable electricity has been examined through geographic, temporal, technological, economic and socio-political dimensions [28].

Choosing the HA for validation of our framework could be biased as justice and wellbeing considerations were taken into consideration by the MaW cooperative from the very beginning in designing the innovative setting. This is by far not the case in general. Nevertheless, using the HA example demonstrates that our framework allows us to analyse energy justice issues for PED-like areas. Obviously, there are also elements to each of the capitals which will be different for each area, and the overarching themes of recognitional, procedural, and distributional justice overlap for some of these capitals. However, this overlap allows them to be considered from different perspectives which may provide added benefit when other such areas are examined. It is hard to discuss natural capital without also discussing physical capital, and human capital is often interlinked with both financial and social capital.

Hence, we believe that the framework considerably enriches debates on energy justice in PED-like areas. Providing the possibility for ex ante justice considerations in the creation of PED-like cases means that utilizing this framework in governance and planning could significantly increase the chances of these districts forming part of a just transition. Combining the capitals with distributional, procedural, recognitional, global and restorative justice, as well as including intergenerational and intragenerational equity allows for the expression of multiple facets which may produce some overlap, but which help to create a comprehensive picture of energy justice issues in PED-like areas. Future research will have to add evidence on this claimed usefulness and where to improve and adjust respectively.

6. Conclusion and outlook

Enhancing capabilities has been used as a metric for energy justice [7,60,61,87], but rather than focusing on people, our approach focuses on opportunities. Energy justice emerged from an environmental justice background [88,89], and owing to this, environmental concerns are often still taken to be central in looking at justice in the energy transition [90]. However, our framework expands the focus away from environmental (which we include as natural capital) to include other dimensions which may otherwise be understudied. Using the five capitals as outlined above offers an enhancement of previous frameworks [14,15,24,37–39,41,72] as we incorporate what we see as the most salient elements of these to identify potential energy injustices.

Besides academic progress in justice issues, our work has a potential for improving societal practice and encouraging proactive governance towards a just transition. Despite the often-made claim towards "human-centred", there is no inherent relation between striving for PEDs and PEDs taking energy justice issues into account, and there is a potential for increased inequalities and exclusion [91]. Our framework can be used in these contexts to enable stakeholders to address these aspects at the design stage. Only by applying careful considerations from the very beginning when planning PEDs and PED-like areas, will we be able to take justice and wellbeing considerations into account. The HA example also highlights that relying on technological solutions alone is not enough to bring about the required reduction in energy consumption to achieve a PED status. Inhabitants choose to live there not because of its fancy technological set up, but because of the whole package. Physical capital (technological innovation) is one element in an equation which also needs to include financial, social, natural and human capital.

The aim of this paper was to add to energy justice research by providing a robust theoretical basis to analysing PED-like areas with opportunity spaces and wellbeing at its centre. The first and most important result is that looking at the case through the lenses offered by the suggested framework can provide results. It allows approaching the relation between energy innovations and the often-opaque notion of opportunity spaces or capabilities by looking at how different capitals are set together. At the same time, the framework is normatively informed, i.e., the categories are normatively desired categories and allow the aforementioned justice criterion to be taken into account.

Second, examining justice issues in such transition settings really matters. If we are to avoid a business-as-usual approach from engineers or standard investors, it should be ensured that justice and wellbeing are considered when energy innovative living areas are planned and implemented. It seems clear that when developing innovative living spaces based on energy transition ideals of decarbonization, decentralized energy production, and smart innovation justice, wellbeing issues must be integrated from the very beginning in order to ensure residents capabilities are maintained, and ideally enhanced.

The framework promises to shed light on the relation between energy transition and how this can become a just transition in the upcoming field of PED-like areas. There are many potentials fields for future empirical as well as conceptual research, such as research related to planning or implementation processes, and looking at realized wellbeing or policy frame-conditions. The framework appears flexible enough to take different contexts of new energy systems into account in order to provide a solid and enhanced basis for analysis.

Adam Hearn is an Early Stage Researcher completing his PhD at Basel University, as part of the Horizon 2020 Marie Skłodowska-Curie Action SMART-BEEJS project. His research focus is on energy justice,

energy poverty, and Positive Energy Districts.

Paul Burger is Professor and directs the Sustainability Research Group within the Department of Social Sciences, University of Basel, Switzerland. His research focuses on theoretical foundations for sustainable development including its normative basis, on governance of sustainable development and on understanding change of household energy consumption.

Dr. Annika Sohre is a Senior Researcher at the Sustainability Research Group, University of Basel, Switzerland. She has an interdisciplinary academic background in environmental sciences and political science. Currently, she works on a number of projects focusing on governance, energy transitions, particularly change of energy behaviour, energy and climate policies and sustainable development.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie Actions, Innovative Training Networks, Grant Agreement No 812730. This research project is part of the Swiss Competence Centre for Energy Research SCCER CREST, which is financially supported by the Swiss Innovation Agency Innosuisse under Grant No. KTI. 1155000154.

Innovative but unjust? Analysing the opportunities and justice issues within Positive Energy Districts in Europe.

References

[1] S. Bouzarovski, S. Petrova, A global perspective on domestic energy deprivation: Overcoming the energy poverty–fuel poverty binary, Energy Res. Social Sci. 10 (2015) 31–40.
[2] R. Day, G. Walker, N. Simcock, Conceptualising energy use and energy poverty using a capabilities framework, Energy Policy. 93 (2016) 255–264.
[3] N. Healy, J. Barry, Politicizing energy justice and energy system transitions: Fossil fuel divestment and a "just transition", Energy Policy. 108 (2017) 451–459, https://doi.org/10.1016/j.enpol.2017.06.014.
[4] K.E.H. Jenkins, D. Hopkins, Transitions in Energy Efficiency and Demand: The Emergence, Routledge, Diffusion and Impact of Low-Carbon Innovation, 2018.
[5] O. Akizu, G. Bueno, I. Barcena, E. Kurt, N. Topaloğlu, J.M. Lopez-Guede, Contributions of Bottom-Up Energy Transitions in Germany: A Case Study Analysis, Energies. 11 (2018) 849, https://doi.org/10.3390/en11040849.
[6] S. Sareen, H. Haarstad, Bridging socio-technical and justice aspects of sustainable energy transitions, Appl. Energy 228 (2018) 624–632, https://doi.org/10.1016/j.apenergy.2018.06.104.
[7] G. Walker, N. Simcock, R. Day, Necessary energy uses and a minimum standard of living in the United Kingdom: Energy justice or escalating expectations? Energy Res. Social Sci. 18 (2016) 129–138, https://doi.org/10.1016/j.erss.2016.02.007.
[8] E. Druică, Z. Goschin, R. Ianole-Călin, Energy Poverty and Life Satisfaction: Structural Mechanisms and Their Implications, Energies. 12 (2019) 3988, https://doi.org/10.3390/en12203988.
[9] B.K. Sovacool, M.H. Dworkin, Energy justice: Conceptual insights and practical applications, Appl. Energy 142 (2015) 435–444, https://doi.org/10.1016/j.apenergy.2015.01.002.
[10] H. Thomson, C. Snell, Quantifying the prevalence of fuel poverty across the European Union, Energy Policy. 52 (2013) 563–572, https://doi.org/10.1016/j.enpol.2012.10.009.
[11] S. Bosch, M. Schmidt, Wonderland of technology? How energy landscapes reveal inequalities and injustices of the German Energiewende, Energy Research & Social Science. 70 (2020), 101733.
[12] M.J. Burke, J.C. Stephens, Energy democracy: Goals and policy instruments for sociotechnical transitions, Energy Res. Social Sci. 33 (2017) 35–48.
[13] B.K. Sovacool, What are we doing here? Analyzing fifteen years of energy scholarship and proposing a social science research agenda, Energy Research & Social Science. 1 (2014) 1–29, https://doi.org/10.1016/j.erss.2014.02.003.
[14] S. Axon J. Morrissey Just energy transitions? Social inequities, vulnerabilities and unintended consequences 1 1 2020 2020 2020 393 411.
[15] R.J. Heffron, D. McCauley, Achieving sustainable supply chains through energy justice, Appl. Energy 123 (2014) 435–437, https://doi.org/10.1016/j.apenergy.2013.12.034.
[16] K. Jenkins, D. McCauley, R. Heffron, H. Stephan, R. Rehner, Energy justice: A conceptual review, Energy Research & Social, Science 11 (2016) 174–182, https://doi.org/10.1016/j.erss.2015.10.004.
[17] L. Steg, R. Gifford, Sustainable transportation and quality of life, J. Transp. Geogr. 13 (1) (2005) 59–69, https://doi.org/10.1016/j.jtrangeo.2004.11.003.
[18] L. Godin, S. Laakso, M. Sahakian, Doing laundry in consumption corridors: wellbeing and everyday life, Sustainability: Science, Practice and Policy. 16 (2020) 99–113.
[19] A. Monti, D. Pesch, K. Ellis, P. Mancarella, Energy Positive Neighborhoods and Smart Energy Districts: Methods, Tools, and Experiences from the Field, Academic Press, 2016.
[20] B. Alpagut, Ö. Akyürek, E.M. Mitre, Positive Energy Districts Methodology and Its Replication Potential, in, Multidisciplinary Digital Publishing Institute Proceedings 20 (1) (2019) 8, https://doi.org/10.3390/proceedings2019020008.
[21] C. Gollner, EUROPE towards POSITIVE ENERGY DISTRICTS, (n.d.) 182.
[22] White-Paper-PED-Framework-Definition-2020323-final.pdf, (n.d.). https://jpi-urbaneurope.eu/wp-content/uploads/2020/04/White-Paper-PED-Framework-Definition-2020323-final.pdf (accessed April 23, 2021).
[23] D. McCauley, V. Ramasar, R.J. Heffron, B.K. Sovacool, D. Mebratu, L. Mundaca, Energy justice in the transition to low carbon energy systems: Exploring key themes in interdisciplinary research, Appl. Energy 233–234 (2019) 916–921, https://doi.org/10.1016/j.apenergy.2018.10.005.
[24] K. Jenkins, B.K. Sovacool, D. McCauley, Humanizing sociotechnical transitions through energy justice: An ethical framework for global transformative change, Energy Policy. 117 (2018) 66–74, https://doi.org/10.1016/j.enpol.2018.02.036.
[25] B.K. Sovacool, M. Martiskainen, A. Hook, L. Baker, Decarbonization and its discontents: a critical energy justice perspective on four low-carbon transitions, Clim. Change 155 (4) (2019) 581–619, https://doi.org/10.1007/s10584-019-02521-7.
[26] G. Powells, M.J. Fell, Flexibility capital and flexibility justice in smart energy systems, Energy Res. Social Sci. 54 (2019) 56–59, https://doi.org/10.1016/j.erss.2019.03.015.
[27] M.J. Fell, Just flexibility? Nat. Energy 5 (1) (2020) 6–7.
[28] A. Banerjee, E. Prehoda, R. Sidortsov, C. Schelly, Department of Social Sciences, Environmental and Energy Policy Program, Michigan Technological University, 1400 Townsend Drive, Houghton MI 49930, USA, Renewable, ethical? Assessing the energy justice potential of renewable electricity, AIMS Energy. 5 (2017) 768–797, https://doi.org/10.3934/energy.2017.5.768.
[29] S. Milčiuvienė, J. Kiršienė, E. Doheijo, R. Urbonas, D. Milčius, The Role of Renewable Energy Prosumers in Implementing Energy Justice Theory, Sustainability. 11 (2019) 5286, https://doi.org/10.3390/su11195286.
[30] L. Horstink, J.M. Wittmayer, K. Ng, G.P. Luz, E. Marín-González, S. Gährs, I. Campos, L. Holstenkamp, S. Oxenaar, D. Brown, Collective Renewable Energy Prosumers and the Promises of the Energy Union: Taking Stock, Energies. 13 (2020) 421, https://doi.org/10.3390/en13020421.
[31] I. Robeyns, An unworkable idea or a promising alternative? Sen's capability approach re-examined, (2000).
[32] R. Hillerbrand, C. Milchram, J. Schippl, Using the Capability Approach as a normative perspective on energy justice: Insights from two case studies on digitalisation in the energy sector, Journal of Human Development and Capabilities. 1–24 (2021).
[33] J. Lienert, P. Burger, Merging capabilities and livelihoods: analyzing the use of biological resources to improve well-being, Ecol. Soc. 20 (2015) (accessed February 11, 2021), https://www.jstor.org/stable/26270215.
[34] Mehr als Wohnen, Home - MORE THAN LIVING, (n.d.). https://www.mehralswohnen.ch/ (accessed February 11, 2021).
[35] R. Stulz, S. Tanner, R. Sigg, Chapter 16 - Swiss 2000-Watt Society: A Sustainable Energy Vision for the Future, in: F.P. Sioshansi (Ed.), Energy, Sustainability and the Environment, Butterworth-Heinemann, Boston, 2011, pp. 477–496, https://doi.org/10.1016/B978-0-12-385136-9.10016-6.
[36] D.L. Goldblatt, Sustainable Energy Consumption and Society: Personal, Technological, or Social Change? Springer Science & Business Media, 2007.
[37] R. Gillard, C. Snell, M. Bevan, Advancing an energy justice perspective of fuel poverty: Household vulnerability and domestic retrofit policy in the United Kingdom, Energy Res. Social Sci. 29 (2017) 53–61.
[38] J. Lee, J. Byrne, Expanding the Conceptual and Analytical Basis of Energy Justice: Beyond the Three-Tenet Framework, Front. Energy Res. 7 (2019), https://doi.org/10.3389/fenrg.2019.00099.
[39] G. Pellegrini-Masini, A. Pirni, S. Maran, Energy justice revisited: A critical review on the philosophical and political origins of equality, Energy Res. Social Sci. 59 (2020) 101310, https://doi.org/10.1016/j.erss.2019.101310.
[40] R.J. Heffron, D. McCauley, The concept of energy justice across the disciplines, Energy Policy. 105 (2017) 658–667, https://doi.org/10.1016/j.enpol.2017.03.018.
[41] F. Bartiaux, M. Maretti, A. Cartone, P. Biermann, V. Krasteva, Sustainable energy transitions and social inequalities in energy access: A relational comparison of capabilities in three European countries, Global Transitions. 1 (2019) 226–240.
[42] C. Groves, F. Shirani, N. Pidgeon, C. Cherry, G. Thomas, E. Roberts, K. Henwood, 'The bills are a brick wall': Narratives of energy vulnerability, poverty and adaptation in South Wales, Energy Res. Social Sci. 70 (2020) 101777, https://doi.org/10.1016/j.erss.2020.101777.
[43] N. DellaValle, S. Sareen, Nudging and boosting for equity? Towards a behavioural economics of energy justice, Energy Research & Social Science. 68 (2020), 101589.
[44] S. Avila, Environmental justice and the expanding geography of wind power conflicts, Sustain Sci. 13 (3) (2018) 599–616, https://doi.org/10.1007/s11625-018-0547-4.

[45] E. Creamer, G.T. Aiken, B. van Veelen, G. Walker, P. Devine-Wright, Community renewable energy: What does it do? Walker and Devine-Wright (2008) ten years on, Energy Res. Social Sci. 57 (2019), 101223.
[46] C.G. Monyei, B.K. Sovacool, M.A. Brown, K.E.H. Jenkins, S. Viriri, Y. Li, Justice, poverty, and electricity decarbonization, The Electricity Journal. 32 (1) (2019) 47–51, https://doi.org/10.1016/j.tej.2019.01.005.
[47] P. Burger, V. Bezençon, B. Bornemann, T. Brosch, V. Carabias-Hütter, M. Farsi, S. L. Hille, C. Moser, C. Ramseier, R. Samuel, Advances in understanding energy consumption behavior and the governance of its change–outline of an integrated framework, Front. Energy Res. 3 (2015) 29.
[48] C.A. Miller, A. Iles, C.F. Jones, The Social Dimensions of Energy Transitions, Science as Culture. 22 (2) (2013) 135–148, https://doi.org/10.1080/09505431.2013.786989.
[49] U. Liebe, G.M. Dobers, Measurement of Fairness Perceptions in Energy Transition Research: A Factorial Survey Approach, Sustainability. 12 (2020) 8084, https://doi.org/10.3390/su12198084.
[50] I. Campos, E. Marín-González, People in transitions: Energy citizenship, prosumerism and social movements in Europe, Energy Res. Social Sci. 69 (2020), 101718.
[51] O. Lindholm, H.u. Rehman, F. Reda, Positioning Positive Energy Districts in European Cities, Buildings. 11 (1) (2021) 19, https://doi.org/10.3390/buildings11010019.
[52] D. Mulvaney, Opening the Black Box of Solar Energy Technologies: Exploring Tensions Between Innovation and Environmental Justice, Science as Culture. 22 (2) (2013) 230–237, https://doi.org/10.1080/09505431.2013.786995.
[53] F. Gralla, D.J. Abson, A.P. Møller, D.J. Lang, H. von Wehrden, Energy transitions and national development indicators: A global review of nuclear energy production, Renew. Sustain. Energy Rev. 70 (2017) 1251–1265, https://doi.org/10.1016/j.rser.2016.12.026.
[54] M. Lacey-Barnacle, Proximities of energy justice: contesting community energy and austerity in England, Energy Res. Social Sci. 69 (2020) 101713, https://doi.org/10.1016/j.erss.2020.101713.
[55] B.K. Sovacool, M. Burke, L. Baker, C.K. Kotikalapudi, H. Wlokas, New frontiers and conceptual frameworks for energy justice, Energy Policy. 105 (2017) 677–691, https://doi.org/10.1016/j.enpol.2017.03.005.
[56] S.E. Bell, C. Daggett, C. Labuski, Toward feminist energy systems: Why adding women and solar panels is not enough☆, Energy Res. Social Sci. 68 (2020), 101557.
[57] F. Martín-Consuegra, J.M. Gómez Giménez, C. Alonso, R. Córdoba Hernández, A. Hernández Aja, I. Oteiza, Multidimensional index of fuel poverty in deprived neighbourhoods. Case study of Madrid, Energy Build. 224 (2020) 110205, https://doi.org/10.1016/j.enbuild.2020.110205.
[58] N. Willand T. Moore R. Horne S. Robertson Retrofit Poverty: Socioeconomic Spatial Disparities in Retrofit Subsidies Uptake 1 1 2020 2020 2020 14 35 10.5334/bc.13.
[59] F. Bartiaux, C. Vandeschrick, M. Moezzi, N. Frogneux, Energy justice, unequal access to affordable warmth, and capability deprivation: A quantitative analysis for Belgium, Appl. Energy 225 (2018) 1219–1233.
[60] J. Assa, C. Lengfelder, Can Enhancing Capabilities Promote Energy Justice? An Agent-Based Model Approach, Mendeley Data. 1 (2020).
[61] T.E. De Wildt, E.J.L. Chappin, G. van de Kaa, P.M. Herder, I.R. van de Poel, Conflicted by decarbonisation: Five types of conflict at the nexus of capabilities and decentralised energy systems identified with an agent-based model, Energy Res. Social Sci. 64 (2020), 101451.
[62] A. Sen, Commodities and Capabilities, Oxford University Press, 1999 https://ideas.repec.org/b/oxp/obooks/9780195650389.html (accessed February 19, 2021).
[63] Human Development Index (HDI) | Human Development Reports, (n.d.). http://hdr.undp.org/en/content/human-development-index-hdi (accessed February 12, 2021).
[64] S. Belda-Miquel, V. Pellicer-Sifres, A. Boni, Exploring the Contribution of Grassroots Innovations to Justice: Using the Capability Approach to Normatively Address Bottom-Up Sustainable Transitions Practices, Sustainability. 12 (2020) 3617.
[65] M.E.P. Seligman, Flourish: A Visionary New Understanding of Happiness and Well-being, Simon and Schuster, 2012.
[66] N.D. Rao, J. Min, Decent Living Standards: Material Prerequisites for Human Wellbeing, Soc Indic Res. 138 (1) (2018) 225–244, https://doi.org/10.1007/s11205-017-1650-0.
[67] D. Coates, P. Anand, M. Norris, Housing, happiness and capabilities: A summary of the international evidence and models, Open Discussion Papers in Economics, 2015.
[68] B.K. Sovacool, R.J. Heffron, D. McCauley, A. Goldthau, Energy decisions reframed as justice and ethical concerns, Nat. Energy 1 (2016) 1–6, https://doi.org/10.1038/nenergy.2016.24.
[69] S. Higginson, M. Thomson, T. Bhamra, "For the times they are a-changin": the impact of shifting energy-use practices in time and space, Local Environment. 19 (5) (2014) 520–538, https://doi.org/10.1080/13549839.2013.802459.
[70] D. McCauley, A. Brown, R. Rehner, R. Heffron, S. van de Graaff, Energy justice and policy change: An historical political analysis of the German nuclear phase-out, Appl. Energy 228 (2018) 317–323, https://doi.org/10.1016/j.apenergy.2018.06.093.
[71] G. Mattioli, I. Philips, J. Anable, T. Chatterton, Vulnerability to motor fuel price increases: Socio-spatial patterns in England, J. Transp. Geogr. 78 (2019) 98–114, https://doi.org/10.1016/j.jtrangeo.2019.05.009.
[72] M. Feenstra, G. Özerol, Energy justice as a search light for gender-energy nexus: Towards a conceptual framework, Renew. Sustain. Energy Rev. 138 (2021) 110668, https://doi.org/10.1016/j.rser.2020.110668.
[73] L. Steg, G. Perlaviciute, E. van der Werff, Understanding the human dimensions of a sustainable energy transition, Front. Psychol. 6 (2015), https://doi.org/10.3389/fpsyg.2015.00805.
[74] B. Bornemann, A. Sohre, P. Burger, Future governance of individual energy consumption behavior change—A framework for reflexive designs, Energy Res. Social Sci. 35 (2018) 140–151.
[75] J. Pitt, C. Nolden, Post-Subsidy Solar PV Business Models to Tackle Fuel Poverty in Multi-Occupancy Social Housing, Energies. 13 (2020) 4852, https://doi.org/10.3390/en13184852.
[76] S. Yang, J.G. Pernot, C.H. Jörin, H. Niculita-Hirzel, V. Perret, D. Licina, Energy, indoor air quality, occupant behavior, self-reported symptoms and satisfaction in energy-efficient dwellings in Switzerland, Build. Environ. 171 (2020) 106618, https://doi.org/10.1016/j.buildenv.2019.106618.
[77] Das 2000-Watt-Areal, 2000-Watt-Areale. (n.d.). https://www.2000watt.swiss/ (accessed February 11, 2021).
[78] J. Lawson, Path Dependency and Emergent Relations: Explaining the Different Role of Limited Profit Housing in the Dynamic Urban Regimes of Vienna and Zurich, Housing, Theory and Society. 27 (3) (2010) 204–220, https://doi.org/10.1080/14036090903326437.
[79] M. Probst, «mehr als wohnen» und die 2000-Watt-Gesellschaft, mehr als wohnen. (n.d.) 56.
[80] J. Drouilles, S. Lufkin, E. Rey, Energy transition potential in peri-urban dwellings: Assessment of theoretical scenarios in the Swiss context, Energy Build. 148 (2017) 379–390.
[81] Vivir aquí, La pinada. (n.d.). https://www.barriolapinada.es/vivir-aqui/ (accessed February 17, 2021).
[82] setplan_smartcities_implementationplan.pdf, (n.d.). https://setis.ec.europa.eu/system/files/setplan_smartcities_implementationplan.pdf (accessed February 11, 2021).
[83] S. Hall, K.E. Roelich, M.E. Davis, L. Holstenkamp, Finance and justice in low-carbon energy transitions, Appl. Energy 222 (2018) 772–780, https://doi.org/10.1016/j.apenergy.2018.04.007.
[84] E. Allen, H. Lyons, J.C. Stephens, Women's leadership in renewable transformation, energy justice and energy democracy: Redistributing power, Energy Res. Social Sci. 57 (2019) 101233, https://doi.org/10.1016/j.erss.2019.101233.
[85] A. Wüste, P. Schmuck, Bioenergy Villages and Regions in Germany: An Interview Study with Initiators of Communal Bioenergy Projects on the Success Factors for Restructuring the Energy Supply of the Community, Sustainability. 4 (2012) 244–256, https://doi.org/10.3390/su4020244.
[86] J. Lowitzsch, C.E. Hoicka, F.J. van Tulder, Renewable energy communities under the 2019 European Clean Energy Package – Governance model for the energy clusters of the future? Renew. Sustain. Energy Rev. 122 (2020) 109489, https://doi.org/10.1016/j.rser.2019.109489.
[87] A. Melin, D. Kronlid, Energy Scenarios and Justice for Future Humans : An Application of the Capabilities Approach to the Case of Swedish Energy Politics, Etikk i Praksis. 13 (2019) 39–54.
[88] S.H. Baker, The Energy Justice Stakes Embedded in the Net Energy Metering Policy Debates, Beyond Zero-Sum Environmentalism (Sarah Krakoff et al., Eds., Environmental Law Institute 2019). (2019).
[89] S. Bouzarovski, S. Tirado Herrero, S. Petrova, D. Ürge-Vorsatz, Unpacking the spaces and politics of energy poverty: path-dependencies, deprivation and fuel switching in post-communist Hungary, Local Environment. 21 (2016) 1151–1170.
[90] M. Graff, S. Carley, M. Pirog, to 2017 with a Closer Look at the Energy Justice Field, Policy Studies Journal. 47 (S1) (2019) S17–S44, https://doi.org/10.1111/psj.v47.S110.1111/psj.12316.
[91] B.K. Sovacool, Who are the victims of low-carbon transitions? Towards a political ecology of climate change mitigation, Energy Res. Social Sci. 73 (2021) 101916, https://doi.org/10.1016/j.erss.2021.101916.
[92] P. Burger, M. Christen, Ed. Basil Bornemann, Sustainability, Well-Being and Justice. Handbook of Democracy and Sustainability, Routledge, London, 2021. In preparation.